10/030704
JC13 Rec'd PCT/PTO 14 JAN 2002

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GR 99 P 2280

Description

Method for controlling the transmitting power in a radio communications system

The invention relates to a method for controlling the transmitting power in a radio communications system, particularly a mobile radio system.

In radio communications systems, for example the second-generation European mobile radio system GSM (Global System for Mobile Communications), information such as, for example, voice, image information or other data is transmitted with the aid of electromagnetic waves via a radio interface. The radio interface relates to a link between a base station and a multiplicity of subscriber stations, where the subscriber stations can be, for example, mobile stations or stationary radio stations. The electromagnetic waves are radiated by means of carrier frequencies which are within a frequency band provided for the respective system. For future radio communications systems, for example the UMTS (Universal Mobile Telecommunication System) or other third-generation systems, frequencies are provided in the frequency band of approx. 2000 MHz. For the third mobile radio generation UMTS, two modes are provided, one mode designating FDD (Frequency Division Duplex) operation and the other mode designating TDD (Time Division Duplex) operation. These modes are used in different frequency bands, both modes supporting a so-called CDMA (Code Division Multiple Access) subscriber separation method.

In mobile radio systems using subscriber separation based on a CDMA method, fast power control, particularly of the mobile radio stations, is necessary

in order to ensure reliable reception of all existing communication links at the location of the base station with at the same time little disturbance due to interference from adjacent transmission channels. Fast transmitting power control is required, in particular, for real-time services such as voice transmission at low rates. According to the prior art as disclosed, for example, in the document ARIB "Japan's Proposal for Candidate Radio Transmission Technology on IMT-2000:W-CDMA", June 1998, Japan, pp. 39 to 42, fast transmitting power control based on a closed control loop and an open control loop is implemented for the FDD mode. Whether the open control loop or closed control loop is used depends on the type of the respective transmission channel. The fast closed control loop is based on so-called TPC (Transmitter Power Control) bits which are periodically signaled by the facility of the radio communications system which has the control in each case to the other facility. Thus, a base station controls the transmitting power of the subscriber station and vice versa.

For the purpose of harmonization between the two modes of the UMTS mobile radio system, such a principle of transmitting power is also to be used, in principle, for the TDD mode. However, simulations have shown that, for example at a subscriber station speed of greater than 10 km/h, fast transmitting power control brings no further gain with respect to an interference situation at the location of the receiving radio station but, in contrast, can even be disadvantageous. The same result also applies to the FDD mode.

From WO 99/18702, a method for power control is known in which an inner loop increases or decreases, respectively, the transmitting power by means of a

measured transmission quality, an outer loop specifying threshold values for the signal quality.
Both the inner loop and the outer loop are arranged as a common block in the base station and/or with the subscriber.

From Sampath A. et al.: "On settings reverse link target SIR in a CDMA system" Phoenix, May 4-7, 1997, New York, IEEE, US. Vol. Conf. 47, 4th May 1997 (1997-05-04), pages 929-933, XP000736744 ISBN:0-7803-3660-7, a method for power control is known in which a subscriber is requested by a base station to adapt his transmitting power, this request being based on a measured signal-to-interference ratio (SIR) value. The control loop itself consists of an inner loop and an outer loop, the inner loop performing the power control and the outer loop being responsible for setting or determining a value which corresponds to the SIR value. The outer loop sets the target values for the inner loop.

The invention is based on the object of specifying a method which provides for improved transmitting power control in a radio communications system whilst avoiding the abovementioned disadvantages of the known method for transmitting power

control. This object is achieved by means of the method having the features of claim 1. Advantageous further developments of the invention can be found in the subclaims.

According to the invention, the transmitting power of a radio station is varied by means of an inner control loop for fast transmitting power control within a transmitting power interval predetermined for slow transmitting power control by an outer control loop. This control can be carried out both for a subscriber station and for a base station of the radio communication system.

The method according to the invention advantageously provides that a transition, for example from fast to slow transmitting power control can be carried out by dimensioning the transmitting power interval of the outer control loop, in order to implement transmitting power control by means of the slow outer control loop, for example at higher speeds of the subscriber station, whereas the fast inner control loop is used at low speeds of the subscriber station. In this exemplary case, the influence of the slow transmitting power control on the fast transmitting power control increases with increasing speed of the subscriber station until a point is reached at which the transmitting power interval becomes zero. From this point on, the transmitting power is exclusively determined by the slow transmitting power control. This method can be advantageously used, for example, both in the TDD mode and in the FDD mode of the UMTS mobile radio system.

Exemplary embodiments of the invention will be explained in greater detail by means of the attached

drawings, in which

figure 1 shows a block diagram of a radio communications system, particularly of a mobile radio system,

figure 2 shows a diagrammatic representation of the structure of a TDD radio interface,

figure 3 shows a diagrammatic representation of the signaling between a subscriber station UE and a base station NB with a transmitting power control according to the invention,

figure 4 shows a block diagram of an exemplary implementation of the inner and outer control loop in a transceiver device of a base station or, respectively, of a subscriber station,

figure 5 shows a representation of the relationship between the weighting factor d, a characteristic value BER determined and a carrier/interference ratio CIR with respect to the outer control loop of figure 4, and

figure 6 shows an exemplary dimensioning of transmitting power intervals for a number of subscriber stations within a certain dynamic range.

Figure 1 shows a part of a mobile radio system as an example of the structure of a radio communications system. A mobile radio system in each case consists of a multiplicity of mobile switching centers MSC which belong to a switching subsystem (SSS) and are networked together or, respectively, establish access to a fixed network, and of in each case

one or more base station subsystems (BSS) connected to these mobile switching centers MSC. A base station subsystem BSS, in turn, has at least one RNC (Radio Network Controller) facility for assigning radio resources and at least one base station NB (node B) in each case connected thereto. A base station NB can set up connections to subscriber stations UE (User Equipment) such as, e.g. mobile stations or other mobile and stationary terminals, via a radio interface. Each base station NB forms at least one radio cell Z. As a rule, the size of the radio cell is determined by the range of a general signaling channel (BCCH - Broadcast Control Channel) which is transmitted with an in each case maximum and constant transmitting power by the base stations NB1, NB2. With sectorization or with hierarchical cell structures, a number of radio cells can also be supplied for each base station NB. The functions of this structure can be transferred to other radio communications systems in which the invention can be used.

The example of figure 1 shows a subscriber station UE which is constructed as a mobile station and which moves with a speed V in the radio cell Z of the base station NB. The subscriber station UE has set up a connection to the base station NB over which the signal of a selected service is transmitted in the uplink UL and downlink DL. During the call, the subscriber station UE periodically evaluates transmission characteristics of the radio interface to the base station supplying it and to other base stations NB surrounding the subscriber station UE in order to request an increase in transmitting power from the base station NB in the case of a worsening of the transmission quality or, for example, a handover to an adjacent base station. The same applies in the case

of an improvement in the quality of transmission when a possible lowering of the transmitting power is signaled in order to minimize the interference in the radio cell.

The subscriber station UE controls the transmitting power of the base station NB by means of signaling messages in which it specifies, for example, a measured variation of the transmission characteristics by specifying a variation of a characteristic value BER or its average value BERavg averaged over a time interval. The time interval selected for forming the average can be, for example, the periodicity of the outer control loop. The characteristic value BER will be, for example, a bit error rate, a time frame error rate, a path attenuation, an interference situation at the location of the subscriber station UE and combinations of these parameters. The variation of the characteristic value BER can be determined additionally or alternatively also by means of the general signaling channel BCCH transmitted at a constant transmitting power. The same method for controlling the transmitting power of the subscriber station UE is carried out by the base station NB. After appropriately evaluating the transmission characteristics, it signals an increase or decrease in transmitting power to the subscriber station UE. According to the prior art mentioned in the introduction, this signaling is carried out, for example, by a specific TPC (Transmitter Power Control) bit for the FDD mode of the ARIB.

The frame structure of the radio transmission in the TDD mode of the UMTS mobile radio system in which the method according to the invention can be advantageously used can be seen in figure 2. According to a TDMA (Time Division Multiple Access) component, a division of a broadband frequency range into a number of timeslots ts of the same period, for example 16 timeslots ts0 to

ts16, is provided which form a time frame fr.

A frequency band B extends over a particular frequency range. Some of the timeslots are used for transmitting signals in the downlink DL and some of the timeslots for transmitting signals in the uplink UL. An asymmetry ratio of 3:1 in favor of the downlink DL is shown by way of example. In this TDD transmission method, the frequency band B for the uplink UL corresponds to the frequency band B for the downlink DL. The same is repeated for other carrier frequencies. A large variety of asymmetric resource allocations can be performed by means of the variable allocation of the timeslots ts for uplink or downlink UL, DL.

Within the timeslots ts, information of a number of links is transmitted in bursts. The data d are spread individually for each connection with a fine structure, a spreading code c, so that at the receiving end, for example, n connections can be separated by this CDMA (Code Division Multiple Access) component. Spreading individual symbols of the data d has the effect that Q chips of duration T_{chip} are transmitted within the symbol period T_{sym}. The Q chips form the connection-related spreading code c.

The parameters of the radio interface used for both transmission modes are advantageously:

Chipping rate:	4.096 Mcps
Frame period:	10 ms
Number of timeslots:	16
Period of one timeslot:	625 µs
Chips per timeslot:	2560
Spreading factor:	variable
Type of modulation:	QPSK
Bandwidth:	5 MHz
Frequency reuse value:	1

These parameters provide for the best possible harmonization of the TDD mode and the FDD mode for the 3rd-generation mobile radio.

Figure 3 shows by way of example the signaling between the subscriber station UE and the base station NB in the embodiment of the method according to the invention. As will also be explained with respect to figure 4 in the text which follows, the outer control loop in the base station NB is used both for controlling the transmitting power of the base station NB and for controlling the transmitting power of the subscriber station UE.

The subscriber station UE conducts measurements with respect to the transmission characteristics of the radio interface during the signal transmission in the established connection to the base station NB. As already described with respect to figure 1, these measurements relate to, for example, a determination of a variation of the characteristic value BER over a particular time interval, an interference situation at the current site of the subscriber station UE and/or a path attenuation determined. The path attenuation is determined, for example, by means of the general signaling channel BCCH since, as a rule, the subscriber station UE knows the transmitting power of this channel. The interference and the path attenuation can be averaged over a time interval in accordance with the characteristic value BER and the respective average values can be signaled to the base station NB where they are evaluated in the outer control loop.

According to the method according to the invention, in addition to an average transmitting power a respective transmitting power interval Pint and a target carrier/interference ratio (CIR) for the base station NB and the subscriber station UE are determined, and signaled

in each case, in the outer control loop of the basestation NB. The

target CIR ensures adequate transmission quality and must be correspondingly adapted to the current transmission conditions. The respective inner control loop can perform rapid transmitting power control within the transmitting power interval Pint determined and signaled. This rapid transmitting power control is effected via the abovementioned TPC bits which in each case result in an increase or reduction of the transmitting power by a certain value in dB. The transmitting power interval Pint can be signaled as an absolute value or as a value of a maximum transmitting power Pmax and a minimum transmitting power Pmin or, respectively, as a relative value with respect to the average transmitting power.

Figure 4 shows by way of example an implementation of the combination of an inner control loop and outer control loop according to the invention in a transceiver device of the base station NB or also the subscriber station UE. In principle, the structure corresponds to the structure of figure 3.5-5, on page 40 of the abovementioned prior art of the ARIB. The received signals are filtered in a so-called matched filter MF and supplied to a detector device JDD. In the example, the detector device JDD is constructed as a known joint detection detector. This detector device JDD has only a limited dynamic range within which it can detect parallel signals, separated by spreading codes, of a number of sources. Among other things, it is for this reason that the transmitting power of the various sources must be very accurate in order to prevent this dynamic range from being exceeded and thus the quality of reception being degraded for all parallel connections.

From the detected signals, a carrier/interference ratio CIR is determined in the inner

loop. The carrier/interference ratio CIR is used as a basis for optimum transmitting power control both by the fast and the slow transmitting power control since the interference situation at the receiver represents the most important criterion for reliable reception of the signals.

The received signals are decoded in a decoding device DC following the detector device JDD, and a respective characteristic value BER is determined. This characteristic value BER is then compared with a target BER in the outer control loop and a difference dBER between the two values is calculated. The difference is then weighted by a weighting factor g and added to a target CIR(i) of a preceding control interval i. The resulting current target CIR(i+1), or target CIR, is delayed in the same manner by means of a delay device DEL and then taken into consideration for the calculation of the subsequent target value. The current target CIR is used for fast transmitting power control in the inner control loop as a basis for increasing or decreasing the transmitting power by signaling TPC bits.

In a further device of the outer control loop, the characteristic value BER is averaged. The averaging can be done, for example, over a time interval of 50 ms to 5 s for the exemplary UMTS mobile radio system. This time interval defines the periodicity for the transmitting power control of the outer control loop. According to the said prior art, fast transmitting power control is done at a periodicity of 0.625 ms. From the average BERavg of the characteristic value BER, a variation of the

transmission characteristics of the radio interface can be determined, the variation being caused, for example, by a movement of the subscriber station UE at a certain speed V. In dependence on the variation, an average transmitting power and a relative maximum transmitting power Pmax and a minimum transmitting power Pmin are then defined. The inner control loop can perform fast transmitting power control within this transmitting power interval Pint.

The maximum Pmax and minimum Pmin transmitting power can be dimensioned periodically in accordance with the time interval for averaging or for the case where the variation drops below a predetermined threshold value. As the variation of the characteristic value BER becomes smaller over the time interval, the transmitting power interval Pint is correspondingly reduced. This means, for example, that at a higher speed V of the subscriber station UE, the fast transmitting power control is progressively replaced by the slow transmitting power control since the inner control loop can no longer perform transmitting power control for a transmitting power interval Pint of zero. Thus, there is a slow transition from the fast transmitting power control to a slow transmitting power control, the limits for the absolute transition or, respectively, the point at which the transmitting power interval Pint becomes zero, being administered, for example, by the base station NB. In this arrangement, this point can also be selected in dependence on the service currently transmitted over the link or on other parameters.

The outer control loop for the subscriber station UE is implemented in such a manner that the subscriber station UE signals characteristic values currently measured BER or characteristic values averaged over a

time interval BERavg to the base

station NB. On the basis of these values, the outer control loop in the base station NB determines a target CIR for the subscriber station UE and a transmitting power interval Pint. The base station NB thus advantageously has a comprehensive capability of controlling the transmitting power control of the subscriber stations UE covered by it. At the same time, this implementation enables the complexity of the subscriber station UE to be reduced considerably since, for example, the calculation of the transmitting power limits is taken over by the central base station NB.

Figure 5 shows the relationship between the characteristic value BER and the carrier/interference ratio CIR, referring to figure 4. It becomes clear that, because of the nonlinearity of the relationship, the weighting factor g in each case depends on an operating point of the outer control loop or, respectively, on the target BER.

Figure 6 shows by way of example a respective dimensioning of the transmitting power interval Pint for connections to a number of subscriber stations UE1 to UE4. The transmitting power intervals Pint are selected in such a manner that an assumed dynamic range of 30 dB of the detector device is not exceeded. Within this dynamic range, each subscriber station UE1 to UE4 is assigned an average transmitting power with a particular transmitting power interval Pint which is in each case defined by a maximum transmitting power Pmax and a minimum transmitting power Pmin. The arrangement of the average transmitting power and of the transmitting power interval Pint within the dynamic range depends, for example, on a distance of the respective subscriber station UE1 to UE4 from the base station NB or, respectively, on individual transmission characteristics due to geographical peculiarities

at the location of the subscriber station. The width of the transmitting power interval Pint, in contrast, depends, for example, on the speed V of the respective subscriber station UE1 to UE4 and on the type of service transmitted, as described. As, for example, the speed V of the subscriber station increases, the transmitting power interval Pint is progressively reduced until it has been reduced to a point as is disclosed by the example of the third subscriber station UE3. In this case, the transmitting power is now only controlled by means of the outer control loop since the inner control loop no longer has any capability for influencing the transmitting power. The specified point for the transmitting power of this third subscriber station UE3 changes within the dynamic range in accordance with a change in the average transmitting power through the outer control loop.